Appendix A

Modeling Report

Mud Lake Slough

WBID 1958

Nutrients and Dissolved Oxygen

March 2013

Region 4 serving the southeast

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1. Watershed Description

Mud Lake Slough (WBID 1958) is located in the southeastern portion of Manatee County with the bottom portion of the watershed draining into Sarasota County (Figure 1).

In order to identify possible pollutant sources in the watershed, the latest land use coverage was obtained from FDEP. Land use data are based on 2006 land cover features categorized according to the Florida Land Use and Cover Classification System (FLUCCS). Table 1 and Figure 2 shows that land use in the Mud Lake Slough watershed is predominantly agricultural. About forty nine percent of the WBID is used for agricultural purposes such as cropland and pastureland (46%), row crops (42%) and tree crops (6%). Upland forest and wetlands account for 14% and 23% of the land uses, respectively.

Table 1 Landuse distribution in WBID 1958 (Mud Lake Slough).

WBID 1958	Urban Residential & Built-Up	Agriculture	Rangeland	Forest	Water	Wetlands	Barren Land	Transportation& Utilities	Total
FLUCCS Code Level 1 Series[1]	1000[3]	2000	3000[4]	4000	5000	6000	7000	8000	
mi^2	0.38	8.73	2.21	2.44	0.03	4.03	0.0	0.0	17.82
percent	2.1%	49.0%	12.4%	13.7%	0.2%	22.6%	0.0%	0.0%	100%

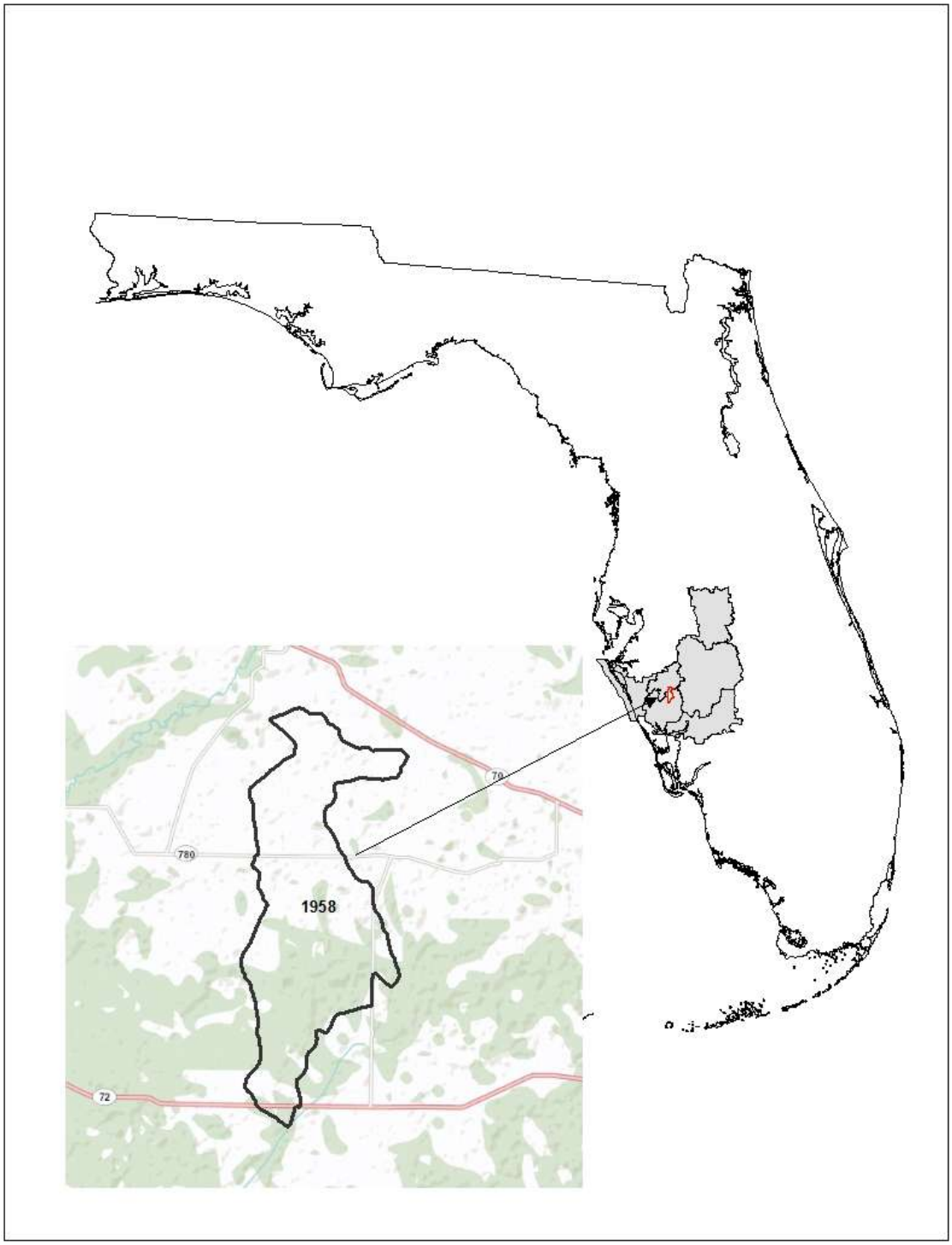

Figure 1 Location Map for WBID 1958

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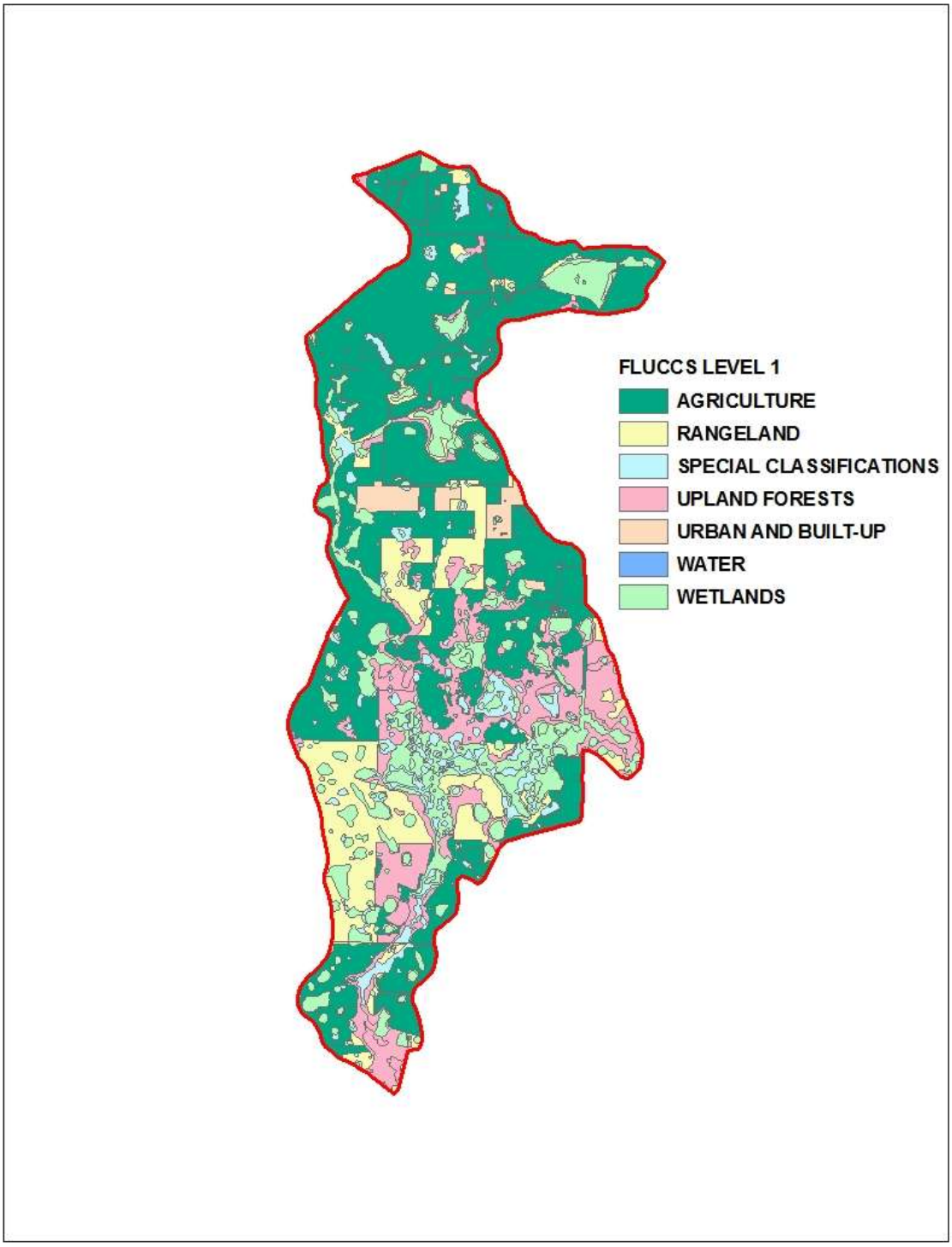

Figure 2 Landuse Distribution for Mud Lake Slough watershed

2. TMDL Targets

The TMDL reduction scenarios were done to achieve a dissolved oxygen concentration of 5 mg/L within the Mud Lake Slough watershed or establish the natural condition.

3. Modeling Approach

A coupled watershed and water quality modeling framework was used to simulate biological oxygen demand (BOD), nutrients (total nitrogen and total phosphorus), and chlorophyll a (Chla) and dissolved oxygen (DO) for the time period of 1999 through 2009. The watershed model provides daily runoff, nutrient and BOD loadings from the watershed. The predicted results from the LSPC model served as boundary conditions to the receiving in-stream model Water Quality Analysis Simulation Program (WASP 7.5) (USEPA, 2009). The WASP model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. Both LSPC and WASP were calibrated to current conditions and used to simulate a natural condition. The WASP model was used to determine the percent reduction in loadings that would be needed to meet water quality standards.

3.1. Mud Lake Slough Watershed Model

The goal of this watershed modeling effort is to estimate runoff (flow), total nitrogen (TN), total phosphorus (TP) and BOD loads and concentrations from the upstream watersheds flowing into Mud Lake Slough. The Loading Simulation Program C++ (LSPC) was used as the watershed model.

LSPC is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream fate and transport model. LSPC is derived from the Mining Data Analysis System (MDAS), which was originally developed by EPA Region 3 (under contract with Tetra Tech) and has been widely used for TMDLs. In 2003, the U.S. Environmental Protection Agency (EPA) Region 4 contracted with Tetra Tech to refine, streamline, and produce user documentation for the model for public distribution. LSPC was developed to serve as the primary watershed model for the EPA TMDL Modeling Toolbox.

3.1.1. Watershed Delineation and Landuse

The drainage area of Mud Lake Slough is presented in Figure 3. For modeling purposes, an LSPC model was setup to include Bud Slough. The model was setup to include 6 sub-basins. The WBID does not have a flow station; hence, the model domain included subbasins of Bud Slough where there is a USGS station. Mud Lake Slough is a tributary to Big Slough.

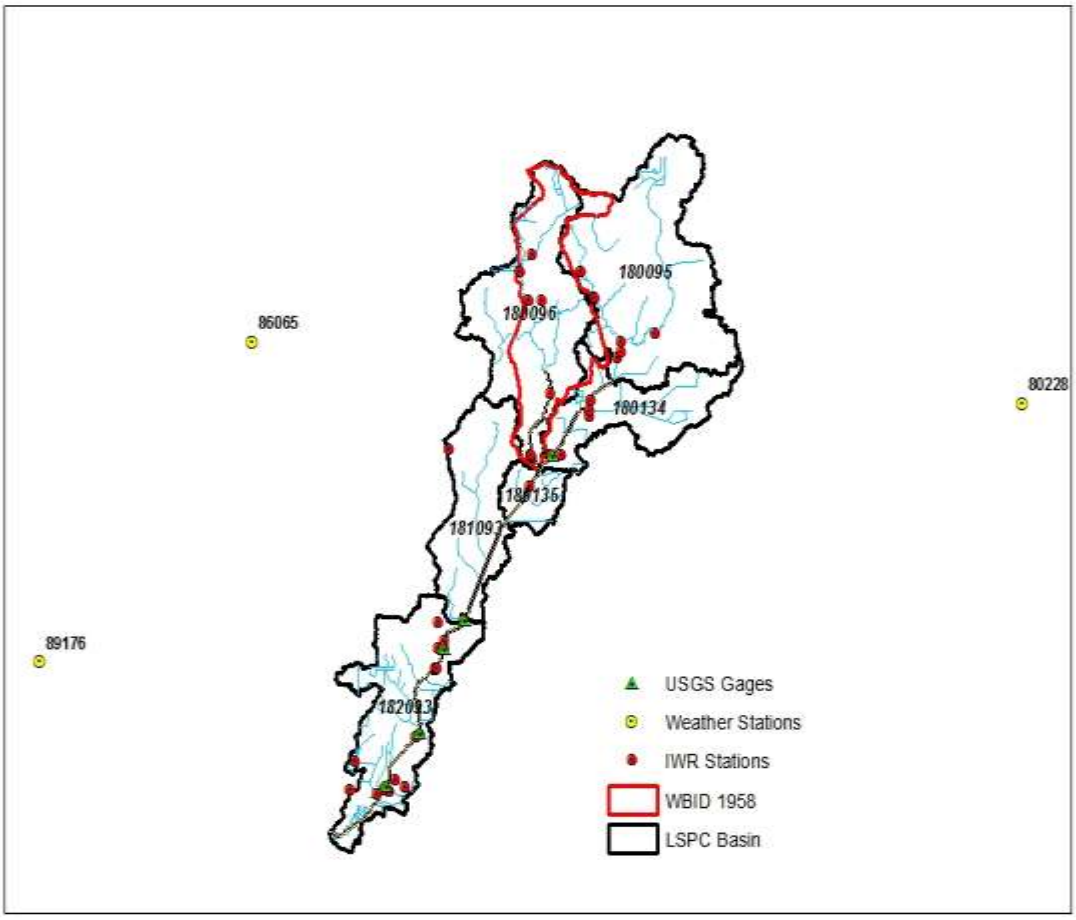

Figure 3 Mud Lake Slough Watershed Delineation

3.2. Mud Lake Slough Watershed Runoff

The LSPC watershed model was developed to simulate hydrologic runoff and pollutant loadings in response to recorded precipitation events for the current and natural conditions.

3.2.1. Meteorological

Rainfall and other pertinent meteorological data was obtained from the National Weather Service (NWS) WBAN station 086065 at Myakka River State Park, FL.

3.2.2. BOD and Nutrient Loadings

Watershed loadings were generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 2). The initial EMC values were derived for each landuse type from a study by Harper and Baker (2003, 2007) and then calibrated to all data available for the watershed. The calibrated EMCs were within the 90% confidence limits of the mean of Harper and Baker (2003, 2007) data. Wetland EMCs were derived from the study of Reiss et.al, (2009). The study summarizes the available literature on nutrient concentrations and hydrology for wetlands in Florida.

Table 2 Calibrated Event Mean Concentration for Landuse Classifications

Landuse	Total Nitrogen	Total Phosphorus	BOD
Cropland	2.9	0.98	3.8
Rangeland/Forest/Undeveloped	1.1	0.06	1.23
Pasture	2.5	0.73	5.1
Urban Area	2.3	0.52	11.3
Water	1.6	0.11	2
Wetlands	2.0	0.06	2.6

BOD and nutrient watershed runoff were determined using EMCs for surface water runoff and interflow runoff and baseflow concentrations for groundwater flow. Table 3 provides the annual average total nitrogen, total phosphorus and BOD loads for the period of record 1999 through 2009. It is these loadings that the TMDL load reduction was calculated from.

Table 3 Mud Lake Slough Nutrient Loads (1999-2009)

	WBID 1958	
Constituent	WLA (kg/yr)	LA (kg/yr)
Total Nitrogen	NA	21028
Total Phosphorus	NA	4112
BOD	NA	34743

3.3. Mud Lake Slough Water Quality Model

The Mud Lake Slough WASP water quality model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen.

3.3.1. WASP Model

The WASP water quality model uses the kinematic wave equation to simulate flow and velocity and the basic eutrophication module to predict dissolved oxygen and Chlorophyll a responses to BOD, total nitrogen and total phosphorus loadings. Widths were taken from satellite imagery and depths from the measured water quality data. Table 4 provides the basic kinetic rates used in the model.

Table 4 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Global Reaeration Rate Constant @ 20 °C (per day)	Covar Method
Sediment Oxygen Demand (g/m2/day)	1.25 for stream segments
Phytoplankton Maximum Growth Rate Constant @20 °C (per day)	3
Phytoplankton Carbon to Chlorophyll Ratio	60
BOD (1) Decay Rate Constant @20 °C (per day)	0.25
Ammonia, nitrate, phosphorus rates @20 °C (per day)	0.05 to 0.1

Table 5 provides a comparison of predicted average concentrations (WASP segment 9) versus the average concentrations of the measured data at the IWR stations 21FLTPA 271136308209218 for 2003 through 2009 (model was run from 1999 to 2009).

Table 5 Existing Condition Observed and Predicted Annual Average Concentrations (2003-2009)

Constituent	Observed	Predicted[1]
Total Nitrogen (mg/l)	0.921	0.912
Total Phosphorus (mg/l)	0.232	0.189
DO (mg/l)	7.7	7.4
BOD (mg/l)[1]	2.06	2.04
Chlorophyll a (ug/l)	2.2	3.1

[1]Wilconxon Signed Rank Test p-values > 0.05 (no significant differences in medians)
[2]BOD data only for 2001 summer @ stations 21FLMANAMSO2 & 21FLMANAMS01

Figure 4 through Figure 8 shows the calibration which compares the observed versus the predicted concentrations.

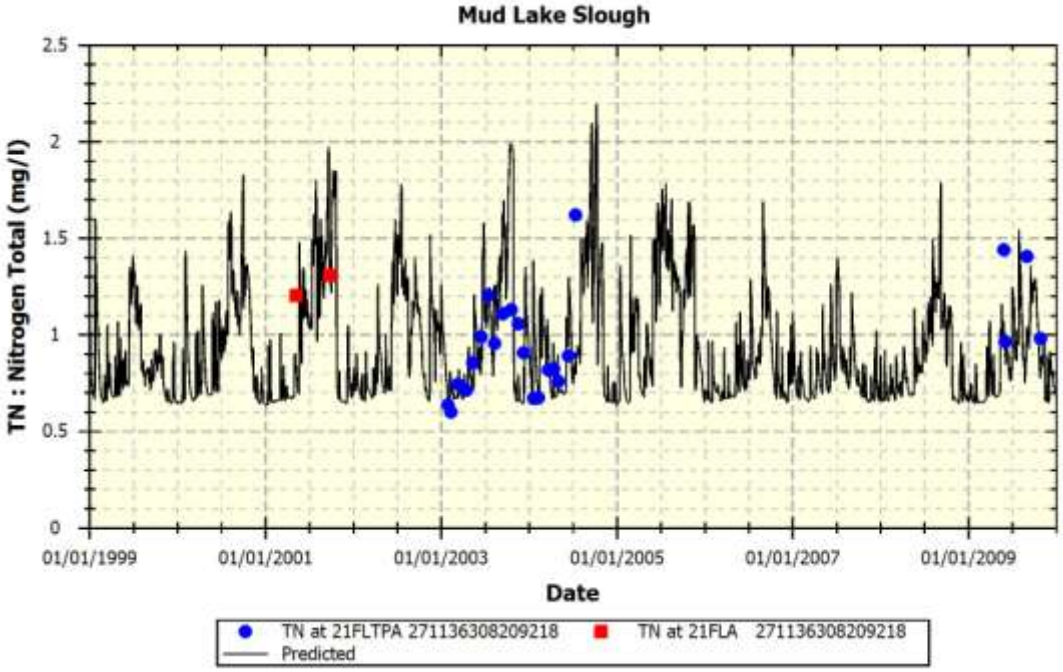

Figure 4 WASP Calibration for Total Nitrogen

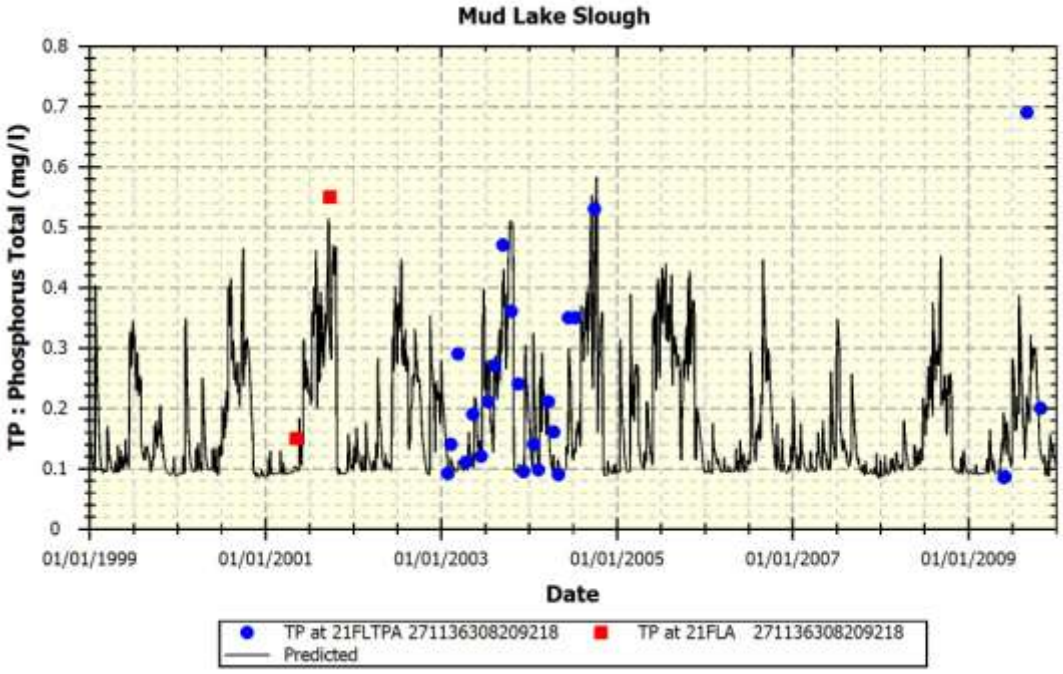

Figure 5 WASP Calibration for Total Phosphorus

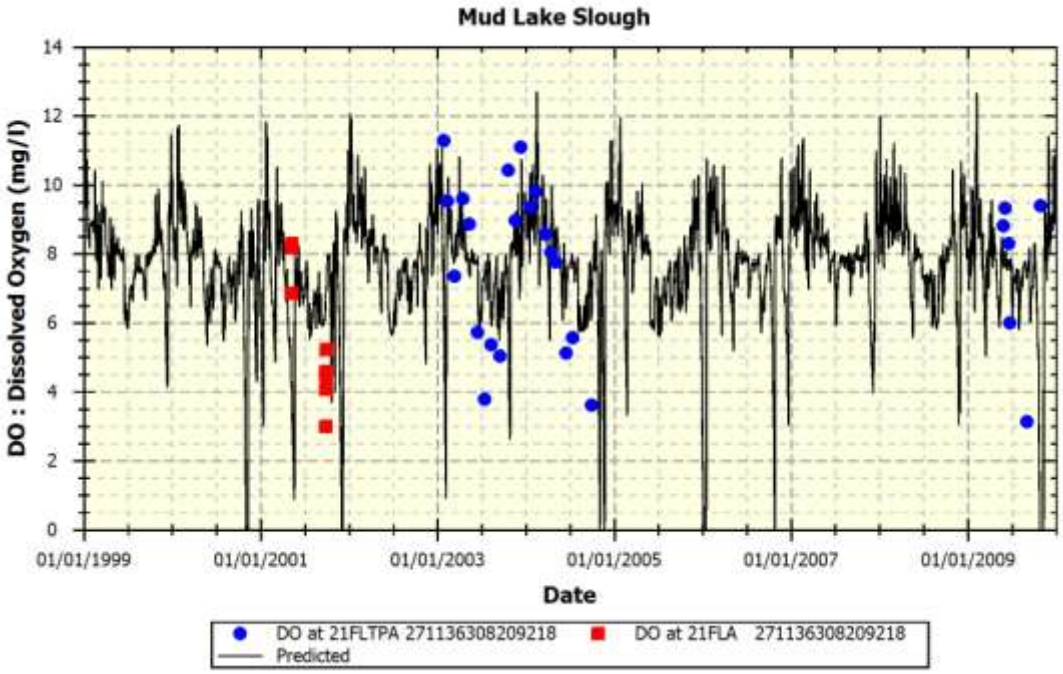

Figure 6 WASP Calibration for Dissolved Oxygen

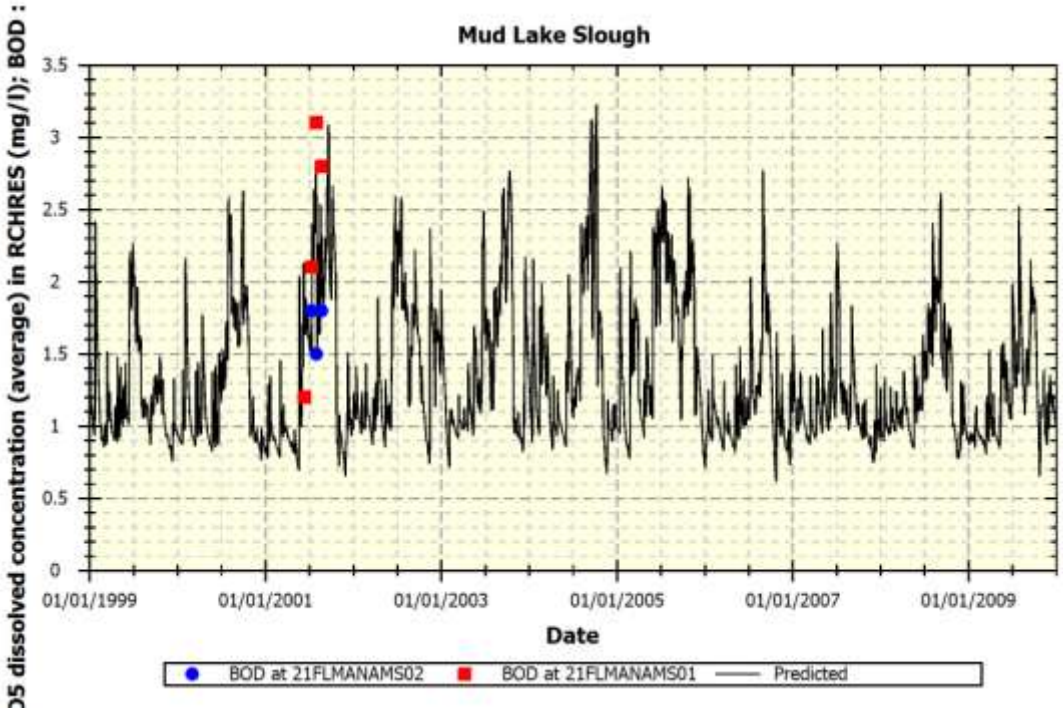

Figure 7 WASP Calibration for BOD

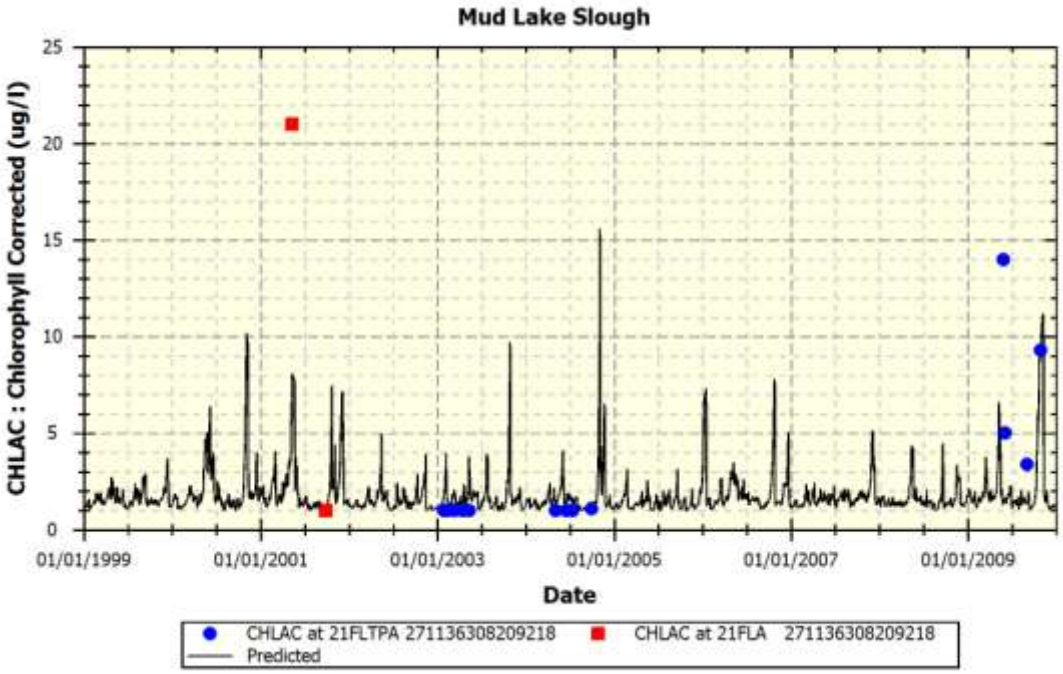

Figure 8 WASP Calibration for Chlorophyll a

4. Modeling Scenarios

Using the calibrated watershed and water quality models, two potential modeling scenarios will be developed. The calibrated model was first used to predict water quality conditions under natural condition (without point sources and returning landuses back to upland forests and wetlands). A second scenario will be developed if water quality standards can be met under natural conditions (balanced flora and fauna, dissolved oxygen greater than 5 mg/L); loads would be reduced from the current conditions until standards are met (balanced flora and fauna, dissolved oxygen greater than 5 mg/L).

4.1. Natural Condition Analysis

Mud Lake Slough sub-basins and upstream land uses were changed from impacted lands to upland forest and wetlands land uses. LSPC was then used to simulate the natural condition nutrient loads (Table 6) which were inputted in to WASP model. Other than the nutrient load reductions the SOD rate was reduced to reflect the reduced loadings.

Table 6 Annual Average Loadings for Natural Condition

	WBID 1958	
Constituent	WLA (kg/yr)	LA (kg/yr)
Total Nitrogen	NA	17394
Total Phosphorus	NA	1115
BOD	NA	23106

Table 7 presents the predicted annual average concentrations under natural conditions. Without the impacts of anthropogenic sources the dissolved oxygen concentration in the Mud Lake Slough still would not achieve the dissolved oxygen standard of 5 mg/l (Figure 9).

Table 7 Natural Condition Annual Average Model Predictions

Constituent	Natural Condition
Total Nitrogen (mg/L)	0.815
Total Phosphorus (mg/L)	0.073
BOD (mg/L)	1.0
DO (mg/L)	8.0
Chlorophyll a (ug/L)	1.9

4.2. TMDL Load Reductions

Because water quality standards cannot be met under natural conditions (Figure 9) no other scenarios were conducted. The TMDL will be set to the natural conditions.

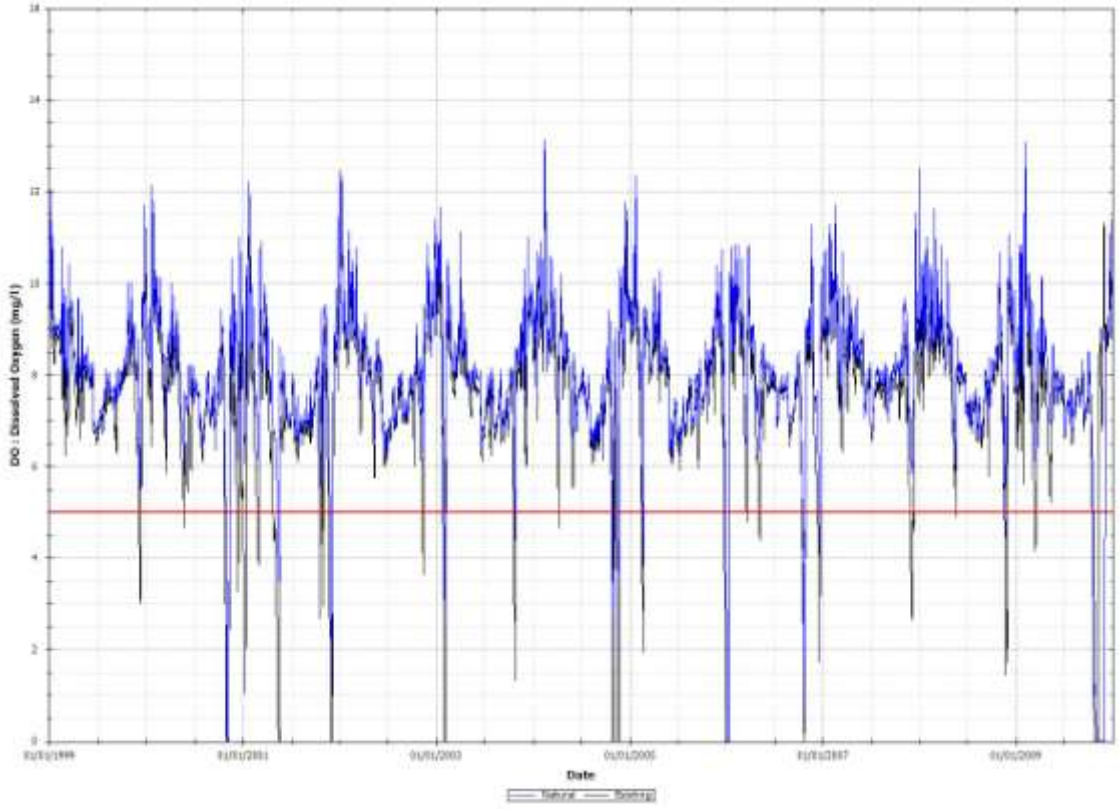

Figure 9 DO Concentration Time Series Under Existing and Natural Condition

5. TMDL Determination

The TMDL load reduction was determined by reducing the current conditions to the natural conditions. The annual average loadings are given in Table 8 along with the prescribed load reductions.

Table 8 TMDL Determination

WBID 1958	Current Condition		TMDL Condition		MS4	LA
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	% Reduction	% Reduction
Total Nitrogen	NA	21028	NA	17394	NA	17
Total Phosphorus	NA	4112	NA	1115	NA	73
BOD	NA	34743	NA	23106	NA	34

References

Harper, H. H. and D.M. Baker. 2003. Evaluation of Alternative Stormwater Regulations for Southwest Florida. Environmental Research & Design, Inc. Orlando, FL.

Reiss, K. C., J. Evans and M.T. Brown. 2009. Summary of the Available Literature on Nutrient Concentrations and Hydrology for Florida Isolated Wetlands. Howard T. Odum Center for Wetlands, Department of Environmental Engineering Sciences, University of Florida, Water Management District, Gainesville, FL.

PBSJ. 2007. Peace River Cumulative Impact Study. Final Report Submitted to Florida Department of Environmental Protection. Tallahassee, Fl.